DECLARATION

I, Kiyoko Kono declare that:

1. I reside at c/o Saikyo Patent Office, Shikishima Building 6th Floor, 2-6, Bingomachi 3-chome, Chuo-ku, Osaka, Japan.

2. I understand and read both the Japanese and the English languages.

3. The attached is a full true and faithful English translation made by me of the priority document of the Japanese Patent Application No. 11-169338, filed on June 16, 1999.

4. I declare further that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the above-identified application or any patent issuing thereon.

Date: June 25, 2003 Name: Kiyoko Kono

Kiyoko Kono

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This is to certify that the annexed is a true copy of the following application as filed with this Office.

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Applicant	:	SHARP KABUSHIKI KAISHA

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[INVENTOR]	
[Domicile or Residence]	c/o SHARP KABUSHIKI KAISHA, 22-22, Nagaike-cho, Abeno-ku, Osaka-shi, Osaka
[Name]	Kazuhiko TSUDA
[INVENTOR]	
[Domicile or Residence]	c/o SHARP KABUSHIKI KAISHA, 22-22, Nagaike-cho, Abeno-ku, Osaka-shi, Osaka
[Name]	Kazuhiro ISHIZUKA
[INVENTOR]	
[Domicile or Residence]	c/o SHARP KABUSHIKI KAISHA, 22-22, Nagaike-cho, Abeno-ku, Osaka-shi, Osaka
[Name]	Hiroyuki OHGAMI
[APPLICANT FOR PATENT]	
[Identification No.]	000005049
[Name]	SHARP KABUSHIKI KAISHA
[Phone]	06-6621-1221
[AGENT]	
[Identification No.]	100103296
[Patent Attorney]	
[Name]	Takaya KOIKE
[Phone]	06-6621-1221
[Office]	Phone 043-299-8466 Intellectual Property Division, Tokyo Intellectual Property Center

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[LIST OF THE ATTACHED DOCUMENTS]

[Item]	Specification	1
[Item]	Drawing(s)	1
[Item]	Abstract	1

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[DOCUMENT] SPECIFICATION

[TITLE OF THE INVENTION] METHOD OF MANUFACTURING LIQUID CRYSTAL DISPLAY APPARATUS

[CLAIMS]

[Claim 1] A method of manufacturing a liquid crystal display apparatus having, on one of a pair of substrates disposed so as to be opposed with a liquid crystal layer therebetween, reflecting means for reflecting incident light from the other substrate, comprising the steps of:

applying a negative photosensitive resin on one of the substrate;

forming asperities in a first region of the applied photosensitive resin film by exposing with various integrals of exposure amount so that the photosensitive resin in the first region is left in different film thicknesses, and forming in a second region of the applied photosensitive resin film a concave portion so that the photosensitive resin in the second region is left in a thickness smaller than those of the first region by exposing the second region with an integral of exposure amount different from those for the first region;

developing the exposed photosensitive resin;

heat-treating the developed photosensitive resin; and

forming a reflecting film on the heat-treated

photosensitive resin.

[Claim 2] The method of manufacturing a liquid crystal display apparatus of claim 1, wherein a reflecting electrode comprising the reflecting film is formed in the first region of the photosensitive resin and that the reflecting electrode is connected to wiring formed in a lower layer of the reflecting electrode in the second region of the photosensitive resin.

[Claim 3] The method of manufacturing a liquid crystal display apparatus of claim 1, wherein a terminal portion is formed in an outside display region on one of the substrates and that the second region of the photosensitive resin is formed in the terminal portion.

[Claim 4] The method of manufacturing a liquid crystal display apparatus of claim 1, wherein the step of exposing the photosensitive resin includes a step of exposing the photosensitive resin using a photomask having a transmitting portion, a light intercepting portion and a semi-transmitting portion, to form the first region in regions corresponding to the transmitting portion and semi-transmitting portion of the photomask, and the second region in a region corresponding to the light intercepting portion of the photomask.

[Claim 5] The method of manufacturing a liquid crystal display apparatus of claim 1, wherein the step of exposing the photosensitive resin includes a step of exposing the photosensitive resin using a first photomask and a step of

exposing the photosensitive resin using a second photomask, to form the first region and the second region with the first and second photomasks, respectively.

[Claim 6] The method of manufacturing a liquid crystal display apparatus of claim 5, wherein the exposure amount at the step of exposing the photosensitive resin using the first photomask and the exposure amount at the step of exposing the photosensitive resin using the second photomask are the same.

[Claim 7] The method of manufacturing a liquid crystal display apparatus of claim 5, wherein uniform and low-illuminance exposure is performed at the step of exposing the photosensitive resin using the first photomask, while uniform and high-illuminance exposure is performed at the step of exposing the photosensitive resin using the second photomask.

[Claim 8] The method of manufacturing a liquid crystal display apparatus of claim 7, wherein circular or polygonal regions are irregularly disposed in the second photomask and that the total area of the circular or polygonal regions is in a range of from 20% to 40% of the total area of the photomask.

[Claim 9] The method of manufacturing a liquid crystal display apparatus of claim 8, wherein the circular or polygonal regions disposed in the second photomask are irregularly disposed so that the center-to-center distances between adjoining regions are in a range of from 5 μm to 50 μm.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical field to which the invention belongs]

The present invention relates to a method of manufacturing a liquid crystal display apparatus which carries out display by reflecting externally incident light.

[0002]

[Prior art]

In recent years, application of liquid crystal display apparatuses to word processors, laptop personal computers, pocket televisions and the like has rapidly been progressing. Of the liquid crystal display apparatuses, reflective-type liquid crystal display apparatuses which carry out display by reflecting externally incident light are attracting attention because the reflective-type liquid crystal display apparatuses are low in power consumption, thin and capable of being reduced in weight since no backlight is necessary.

[0003]

However, in the conventional reflective-type liquid crystal display apparatuses, the brightness and the contrast ratio of the display are dependent on the use environment such as ambient brightness or the use condition. Therefore, at present, high expectations are placed on the realization of a reflective-type liquid crystal display apparatus that has excellent reflection characteristics, can easily be

manufactured with excellent reproducibility and is high in display quality.

[0004]

Japanese Unexamined Patent Publication JP-A 6-75238 discloses a technology to form random and high-density asperities on a reflecting electrode in order to improve the display quality of the reflective-type liquid crystal display apparatus.

[0005]

According to this, a resin layer for adding fine asperities to a reflecting electrode comprises a first photosensitive resin layer patterned with random asperities and a second photosensitive resin layer for making the asperities smoother, and in a mask for patterning the first photosensitive resin layer, circular light intercepting portions are randomly disposed and the total area of the light intercepting portions is not less than 40% of the area of the reflecting plate.

[0006]

By increasing the randomness as described above, the interference due to the repetitive pattern is prevented and the reflecting light is prevented from being colored, and by increasing the density of the asperities, the area of the flat part is reduced to thereby reduce the regular reflection component.

[0007]

Moreover, Japanese Unexamined Patent Publication JP-A 9-90426 discloses a technology to simultaneously expose an asperity forming pattern and contact holes using only one layer of a positive photosensitive resin in order to reduce the process of manufacturing a reflective-type liquid crystal display apparatus.

[0008]

A method of manufacturing a reflective-type liquid crystal display apparatus described in this patent publication will briefly be described with reference to the drawings.

[0009]

Fig. 14 is a cross-sectional view showing the structure of a reflective-type liquid crystal display apparatus formed by the manufacturing method described in the above-mentioned patent publication. Fig. 15 shows cross-sectional views showing the flow of the manufacturing process.

[0010]

As shown in Fig. 14, in the reflective-type liquid crystal display apparatus described in the above-mentioned patent publication, a substrate in which a liquid crystal driving device 24 is formed is used as a reflecting substrate 23, and the following are provided: an aluminum pixel electrode 10 disposed on the reflecting substrate 23; a transparent electrode 12 opposed thereto; a color filter substrate 25 supporting the transparent electrode 12; liquid crystal 11

sandwiched therebetween; a retardation film 15 disposed above the color filter substrate (on the side of the surface not opposed to the liquid crystal); and a polarizer 16 disposed above the retardation film 15.

[0011]

In the reflecting substrate 23, an amorphous silicon transistor is formed on a glass substrate 1 as the liquid crystal driving device 24. As shown in Fig. 14, the liquid crystal driving device 24 comprises Ta as a gate electrode 2 on the glass substrate 1, SiNx as a gate insulating layer 3, a-Si as a semiconductor layer 4, n-type a-Si as an n-type semiconductor layer 5, Ti as a source electrode 7, and Ti as a drain electrode 8.

[0012]

A method of manufacturing the reflecting substrate 23 of the reflective-type liquid crystal display apparatus described in the above-mentioned patent publication will be described with reference to Fig. 15.

[0013]

First, as shown in Fig. 15(a), a positive photosensitive resin 9 is applied to the substrate 1.

[0014]

Then, as shown in Fig. 15(b), exposure is carried out at high illuminance using a photomask having transmitting portions 18 corresponding to the contact hole 30 and, in addition

thereto, transmitting portions 18 at asperity formed portions, as shown in Fig. 16.

[0015]

Then, as shown in Fig. 15(c), by development with a developing solution, the resin in the exposed parts mentioned above is completely removed, so that a resin configuration that is positive with respect to the mask pattern is formed.

[0016]

Then, as shown in Fig. 15(d), by a heat treatment, the resin in the exposed regions is deformed into smooth asperities. However, at this time the exposed regions are flat because the resin has completely been removed by the above-described developing step.

[0017]

Then, as shown in Fig. 15(e), an Al thin film is formed as the reflecting electrode 10, and patterning is performed so that one reflecting electrode 10 corresponds to one transistor.

[0018]

The reflecting electrode 10 of the reflective-type liquid crystal display apparatus described in the above-mentioned patent publication is formed by the above-described process. In such a reflecting substrate 23, since the asperities are formed with the positive photosensitive resin in the exposed portions having been completely removed, the area of the flat part is large. In such a reflecting plate in which

the area of the flat part is large, since the light source is reflected in the flat region, the regular reflection component is large. Since display is difficult to confirm when the light source is reflected, the regular reflection component generally is avoided in the case of the reflective-type display apparatus.

[0019]

Therefore, the regular reflection component of the reflecting plate in the reflective-type liquid crystal display apparatus disclosed in the above-mentioned patent publication do not contribute to the brightness, which results in dark display.

[0020]

[Problems that the invention is to solve]

Compared to the reflective-type liquid crystal display apparatus disclosed in JP-A 9-90426, previously-mentioned JP-A 6-75238 discloses a reflective-type liquid crystal display apparatus adopting a complicated asperity forming process in order to create an ideal scattering condition by improving the density of the asperities of the reflecting plate. According to this apparatus, after application of a first positive photosensitive resin, first exposure development of a sufficient intensity is performed. Then, after the patterning of the asperities are completely performed, the clearances of the asperities are completely filled so that the asperities are smooth. Then, a second positive photosensitive resin is

applied in order to reduce the area of the flat part, and thereafter, only the patterning of the contact hole portions is again performed by performing second exposure development.

[0021]

However, in this process, since the photosensitive resin is applied in two layers, it is necessary to perform the photoprocess (application - exposure - development - heat treatment) of the photosensitive resin twice, so that the cost clearly increases.

[0022]

Further, in the reflective-type liquid crystal display apparatus disclosed in JP-A 9-90426, since one layer of a positive photosensitive resin is used, it is necessary to perform the photoprocess of the photosensitive resin only once, so that the process is simplified and cost reduction can be achieved. However, since it is necessary to remove certainly the photosensitive resin in the contact hole portions, it is inevitable that the positive photosensitive resin in the exposed area in the asperity forming pattern portion is also removed. Consequently, the exposed area is flat, so that in the reflecting plate, the density of the asperities is low and the regular reflection component is large.

[0023]

When dust or the like exists in the regions to be exposed for removing the photosensitive resin, the resin in the parts

that are left unexposed cannot be removed by development. As a result, faulty electrical continuity occurs at contact holes and a signal input terminal portion.

[0024]

The invention is made to solve the above-mentioned problems of the reflective-type liquid crystal display apparatus, and an object thereof is to provide a method of manufacturing a liquid crystal display apparatus with which a liquid crystal display apparatus in which faulty electric continuity does not readily occur and that has excellent reflection characteristics can easily be manufactured with excellent reproducibility.

[0025]

[Means of solving the problems]

In order to achieve the above-mentioned object, the invention provides a method of manufacturing a liquid crystal display apparatus having, on one of a pair of substrates disposed so as to be opposed with a liquid crystal layer therebetween, reflecting means for reflecting incident light from the other substrate, comprising the steps of:

applying a negative photosensitive resin on one of the substrate;

forming asperities in a first region of the applied photosensitive resin film by exposing with various integrals of exposure amount so that the photosensitive resin in the first

region is left in different film thicknesses, and forming in a second region of the applied photosensitive resin film a concave portion so that the photosensitive resin in the second region is left in a thickness smaller than those of the first region by exposing the second region with an integral of exposure amount different from those for the first region;

developing the exposed photosensitive resin;

heat-treating the developed photosensitive resin; and

forming a reflecting film on the heat-treated photosensitive resin.

[0026]

In the above-mentioned method of manufacturing a liquid crystal display apparatus, it is preferable that a reflecting electrode comprising the reflecting film is formed in the first region of the photosensitive resin film and that the reflecting electrode is connected to wiring formed in a lower layer of the reflecting electrode in the second region of the photosensitive resin film.

[0027]

Further, it is also preferable that a terminal portion is formed in an outside display region on one of the substrates and that the second region of the photosensitive resin film is formed in the terminal portion.

[0028]

Still further, it is also preferable that the step of

exposing the photosensitive resin includes a step of exposing the photosensitive resin using a photomask having a transmitting portion, a light intercepting portion and a semi-transmitting portion, to form the first region in regions corresponding to the transmitting portion and semi-transmitting portion of the photomask, and the second region in a region corresponding to the light intercepting portion of the photomask.

[0029]

Yet further, it is also preferable that the step of exposing the photosensitive resin includes a step of exposing the photosensitive resin using a first photomask and a step of exposing the photosensitive resin using a second photomask, to form the first region and the second region with the first and second photomasks, respectively.

[0030]

At this time, it is also preferable that the exposure amount at the step of exposing the photosensitive resin using the first photomask and the exposure amount at the step of exposing the photosensitive resin using the second photomask are the same.

[0031]

Moreover, it is also preferable that uniform and low-illuminance exposure is performed at the step of exposing the photosensitive resin using the first photomask, while

uniform and high-illuminance exposure is performed at the step of exposing the photosensitive resin using the second photomask.

[0032]

Furthermore, it is also preferable that circular or polygonal regions are irregularly disposed in the second photomask and that the total area of the circular or polygonal regions is in a range of from 20% to 40% of the total area of the photomask.

[0033]

Still more, it is also preferable that the circular or polygonal regions disposed in the second photomask are irregularly disposed so that the center-to-center distances between adjoining regions are in a range of from 5 μm to 50 μm.

[0034]

Now, descriptions over how the method of manufacturing a liquid crystal display apparatus of the invention works are given below.

[0035]

According to the invention, by exposing the regions of different patterns of the photosensitive resin applied to the substrate with different integrals of exposure amount on an area basis, a smooth region having high-density asperities and other regions having no high-density asperities can be formed with

a reduced number of steps.

[0036]

That is, there are hardly any flat parts in the asperities formed region because the asperities formed region can be formed into a curved surface by a heat treatment under a condition that there is no part in which the photosensitive resin is completely removed. Consequently, excellent reflection characteristics with a reduced regular reflection component can be realized.

[0037]

At the exposing step, since the negative photosensitive resin in the part intercepted from light by a photomask (light intercepted region) is readily soluble in a developing solution, circular or polygonal pillars or holes are formed, and since the negative photosensitive resin in the part not intercepted from light by the photomask (transmitting region) is not readily soluble in the developing solution, a photosensitive resin film having asperities is formed on the substrate in correspondence with the transmitting region and the light intercepted region of the photomask by developing the photosensitive resin with the developing solution after the exposure.

[0038]

Owing to the use of the photosensitive resin as an interlayer insulating film, the reflecting electrode can be manufactured by a minimum number of steps. By forming the reflecting electrode in the first region of the photosensitive

resin film and connecting the reflecting electrode to the wiring formed in the lower layer of the reflecting electrode in the second region of the photosensitive resin film, that is, removing the resin in regions corresponding to contact holes for connecting the reflecting electrode and a liquid crystal driving device, the photosensitive resin is left over the entire display picture element region except the contact holes, so that asperities in which the area of the flat part is small and which is smooth over the entire picture element region can be formed. As a result, bright reflected light with reduced regular reflection can be obtained.

[0039]

Further, owing to the use of the photosensitive resin as an interlayer insulating film and the formation of a transmitting region corresponding to the terminal portion for inputting an external signal in the second region of the photosensitive resin, the terminal portion can be manufactured by a minimum number of steps.

[0040]

Since the step of exposing the photosensitive resin includes the step of exposing the photosensitive resin using the photomask having the transmitting portion, the light intercepting portion and the semi-transmitting portion, to form the first region in the regions corresponding to the transmitting portion and semi-transmitting portion of the

photomask and the second region in the region corresponding to the light intercepting portion of the photomask, the number of exposures can be reduced to one.

[0041]

Further, since the step of exposing the photosensitive resin includes the step of exposing the photosensitive resin using the first photomask and the step of exposing the photosensitive resin using the second photomask, to form the first and second regions by the first and second photomasks, it is made possible to use photomasks composed of only a transmitting portion and a light intercepting portion, with the result that the design and manufacture of the photomasks is facilitated and the number of exposing steps can be reduced.

[0042]

According to the invention, since the exposure with the first photomask and the exposure with the second photomask are carried out in the same exposure amount, the light quantity adjustment is facilitated, with the result that the throughput of the exposing step can be enhanced.

[0043]

Since uniform and low-illuminance exposure is performed at the step of exposing the photosensitive resin using the first photomask and uniform and high-illuminance exposure is performed at the step of exposing the photosensitive resin using the second photomask, it becomes possible to expose only a convex

formed region in the first region at a high illuminance, so that it is possible that the photosensitive resin is completely left in the first region with more reliability. Here, the high-illuminance exposure indicates an exposure of such an extent of exposure amount that cross-linking of the resin sufficiently progresses in the negative photosensitive resin and the left film amount after the development is larger than substantially 50% of the film thickness before the development, and the low-illuminance exposure indicates an exposure of such an extent of exposure amount that cross-linking of the resin does not sufficiently progress in the negative photosensitive resin and the left film amount after the development is 0% or more and less than 50%, preferably, 10% or more and less than 50% of the film thickness before the development.

[0044]

More specifically, in the negative photosensitive resin formed on the substrate, owing to the low-illuminance exposure with the first photomask, cross-linking of the photosensitive resin in the part subjected to the low-illuminance exposure with the first photomask does not sufficiently progress, so that the film of the photosensitive resin in the part subjected to the low-illuminance exposure is uniformly reduced in thickness by the development with a development solution after the exposure.

[0045]

Moreover, in the negative photosensitive resin formed

on the substrate, by performing the high-illuminance exposure using the second photomask, cross-linking of the photosensitive resin in the part exposed at a high illuminance using the second photomask sufficiently progresses, so that a convex portion being higher by one step than the unexposed part by the second photomask is formed by the development with the developing solution after the exposure and it is possible to form smooth asperities by the resin being deformed in a succeeding heat treatment.

[0046]

As described above, by performing the high-illuminance exposure, the low-illuminance exposure and development on one layer of negative photosensitive resin and then, heat-treating the photosensitive resin, the asperities of the photosensitive resin formed on the substrate are deformed, so that continuous, high-density and smooth asperities without any flat part are formed on the substrate.

[0047]

Further, by forming the reflecting electrode on the heat-treated photosensitive resin having the smooth asperities, excellent reflecting means with a small regular reflection component can be formed.

[0048]

In the invention, the order of the steps of the low-illuminance exposure as the first exposing step and the

high-illuminance exposure as the second exposing step may be opposite to the above-described order.

[0049]

As the process from the exposing step to the developing step, the following two are considered: the process from exposure (the low-illuminance exposure and the high-illuminance exposure) to development; and the process from exposure (the low-illuminance exposure or the high-illuminance exposure) through development and exposure (the high-illuminance exposure or the low-illuminance exposure) to development. In the invention, either of the two processes can be used. However, the former process is preferable in view of the simplification of the process.

[0050]

Further, since the circular or polygonal regions are irregularly disposed in the second photomask, the total area of the circular or polygonal regions is in a range of from 20% to 40% of the total area of the photomask and the circular or polygonal regions are irregularly disposed, the periodicity of the pattern of the asperities of the photosensitive resin formed on the substrate is eliminated, so that the light interference phenomenon can be prevented. As a result, white scattered light without any color can be obtained. Moreover, since the scattered light from the asperities does not biased in a specific direction, uniform scattered light can be obtained.

[0051]

Since the total area of the circular or polygonal regions in the second photomask is in a range of from 20% to 40% of the photomask, the angle of inclination of the asperities of the photosensitive resin formed on the substrate can be controlled so that the light can efficiently be used.

[0052]

Here, the total area of the photomask concretely means the total area of the reflecting electrode. In the case where the area of the circular or polygonal regions in the second photomask is not less than 40%, when the circular or polygonal regions are randomly disposed, adjoining circular or polygonal regions overlap each other into a large pattern, so that the pattern density decreases as a whole and the ratio of the area of the flat part increases. As a result, a reflecting plate with a large regular reflection component is formed. In the case where the area of the circular or polygonal regions in the second photomask is not more than 20%, when the circular or polygonal regions are randomly disposed, the distances between adjoining circular or polygonal regions are too large, so that the distances between convex portions and convex portions or concave portions and concave portions of the configuration of the photosensitive resin formed by development are too large and flat parts are left between convex portions or concave portions when the resin is deformed by heating. As a result,

a reflecting plate with a large regular reflection component is formed. From these, in the invention, the total area of the circular regions in the second photomask is in a range of from 20% to 40% of the total area of the photomask.

[0053]

Here, by irregularly disposing the circular or polygonal regions disposed in the second photomask so that the center-to-center distances between adjoining regions are in a range of from 5 μm to 50 μm, a sufficient number of asperity patterns can be disposed for one picture element of the liquid crystal display apparatus, so that scattered light can be obtained in which there is no difference in characteristics between picture elements.

[0054]

In the case where adjoining circular or polygonal regions are disposed so as not to overlap each other, patterns in which the center-to-center distance is not more than 5 μm are not resolved but become flat because of the limit of resolution of the exposure machine, so that a reflecting plate with a large regular reflection component is formed. Generally, in a liquid crystal display apparatus, since the size of one picture element is not more than approximately 100 μm × 300 μm, to dispose approximately ten or more convex portions or concave portions for one picture element in order to obtain uniform scattering property, it is necessary that the center-to-center distance

is substantially not more than 50 μm. When the center-to-center distance is larger than 50 μm, since the distances between the circular regions are large, the ratio of the area of the flat part increases, so that a reflecting plate with a large regular reflection component is formed. From these, in the invention, the circular or polygonal regions disposed in the second photomask are irregularly disposed so that the center-to-center distances between adjoining circular or polygonal regions are in a range of from 5 μm to 50 μm.

[0055]

[Working examples]

(Embodiment 1)

Now referring to the drawings, a reflective-type liquid crystal display apparatus of Embodiment 1 of the invention is described below. Fig. 1 is a plan view showing a reflecting substrate of a reflective-type liquid crystal display apparatus according to Embodiment 1. Fig. 2 is a cross-sectional view of the reflecting substrate shown in Fig. 1. Fig. 3 shows cross-sectional views showing the flow of the manufacturing process of the substrate.

[0056]

As shown in Figs. 1 and 2, on the reflecting substrate 23 used in the reflective-type liquid crystal display apparatus according to this embodiment, a reflecting electrode 10 is formed, and the surface thereof has smooth asperities

comprising circular concave or convex portions 33. On a glass substrate 1, an amorphous silicon transistor is formed as a liquid crystal driving device 24. The liquid crystal driving device 24 comprises Ta as a gate electrode 2 on the glass substrate 1, SiNx as a gate insulating layer 3, a-Si as a semiconductor layer 4, n-type a-Si as an n-type semiconductor layer 5, Ti as a source electrode 7, and Ti as a drain electrode 8.

[0057]

A signal input terminal portion 27 for inputting signals to a gate bus line and a source bus line comprises a terminal portion electrode 2 of Ta and a terminal connection electrode 26 of ITO formed by patterning simultaneously with the gate bus line and the gate electrode.

[0058]

A manufacturing process of the reflecting substrate 23 of the reflective-type liquid crystal display apparatus according to this embodiment will be described with reference to Fig. 3. In these figures, the pixel region is shown on the left side, and the signal input terminal portion region is shown on the right side.

[0059]

First, as shown in Fig. 3(a), a negative photosensitive resin 9 (the name of the product: FE301N manufactured by Fuji Film Olin) is applied to the glass substrate 1 in a thickness

of 1 to 5 μm. In this embodiment, the resin 9 was applied in a thickness of 3 μm.

[0060]

Then, by using a first photomask 19 in which light intercepting portions 18 corresponding to contact hole portions 30 were disposed as shown in Fig. 4, the region other than the contact hole portions was uniformly exposed at a low illuminance as shown in Fig. 3(b). It is desirable that the exposure amount at this time is 20 mj to 100 mj. In this embodiment, exposure was performed with an exposure amount of 40 mj.

[0061]

Then, by using a second photomask 20 in which the area of transmitting portions 17 was in a range of from 20% to 40% as circular regions in the region other than the contact hole portions 30 as shown in Fig. 5, the region other than the contact hole portions 30 was uniformly exposed at a high illuminance as shown in Fig. 3(c). It is desirable that the exposure amount at this time is 160 mj to 500 mj. In this embodiment, exposure was performed with an exposure amount of 240 mj. At this time, the circular or polygonal transmitting portions 17 of the second photomask were randomly disposed so that the center-to-center distances between adjoining transmitting portions 17 were in a range of from 5 μm to 50 μm, preferably, 10 μm to 20 μm.

[0062]

At this time, the first and the second photomasks were

structured so as to intercept the signal input terminal portion 27 from light as well as the contact holes.

[0063]

Then, as shown in Fig. 3(d), by performing development with a developing solution TMAH (tetramethylammoniumhydrooxide) manufactured by Tokyo Ohka Kogyo Co., Ltd., the resin in the unexposed part (the contact hole portions and the signal input terminal portion) was completely removed, approximately 40%, with respect to the initial film thickness, of the resin in the part exposed at a low illuminance was left, and approximately 80%, with respect to the initial film thickness, of the resin in the part exposed at a high illuminance was left.

[0064]

Then, as shown in Fig. 3(e), by performing a heat treatment at 200℃ for 60 minutes, the resin of the above-described condition was deformed into smooth asperities.

[0065]

Then, as shown in Fig. 3(f), an Al thin film was formed by sputtering as the reflecting electrode 10 on the substrate 1 in a thickness of 2000 Å, and as shown in Figs. 3(g) to (k), patterning was performed so that one reflecting electrode 10 corresponds to one transistor.

[0066]

Specifically, the patterning of the Al electrode serving

as the reflecting electrode 10 was carried out in such a manner that: a photoresist 28 was applied as shown in Fig. 3(g); a portion to be removed for separation of each pixel electrode and the signal input terminal portion 27 were exposed as shown in Fig. 3(h); and development, etching and exfoliation were performed as shown in Figs. 3(i) to (k).

[0067]

By the above-described process, the reflecting electrode 10 having smooth and high-density asperities was formed. In such a reflecting substrate 23, the area of the flat part is reduced, so that ideal reflection characteristics with a small regular reflection component can be realized. Moreover, the number of photoprocesses of the photosensitive resin can be reduced, so that the cost necessary for the manufacture of the reflecting plate can be reduced.

[0068]

Lastly, the reflecting substrate 23 and a color filter substrate for supporting a transparent electrode are bonded together with a spacer therebetween in a manner similar to that of the prior art, liquid crystal is filled, and a retardation film and a polarizer are bonded to the color filter substrate to complete the reflective-type liquid crystal display apparatus according to this embodiment.

[0069]

(Embodiment 2)

Hereinafter, a reflective-type liquid crystal display apparatus according to Embodiment 2 of the invention will be described with reference to the drawings. The reflecting substrate of the reflective-type liquid crystal display apparatus according to this embodiment is the same as the reflecting substrate shown in Fig. 1 but is formed by a different manufacturing method. The manufacturing method will be described with reference to the cross-sectional views shown in Fig. 6.

[0070]

Fig. 6 shows cross-sectional views showing a manufacturing process of the reflecting substrate used in the reflective-type liquid crystal display apparatus according to this embodiment. In these figures, the pixel region is shown on the left side, and the signal input terminal portion region is shown on the right side.

[0071]

First, as shown in Fig. 6(a), the negative photosensitive resin 9 (the name of the product: FE301N manufactured by Fuji Film Olin) is applied to the glass substrate 1 in a thickness of 1 to 5 μm. In this embodiment, the resin 9 was applied in a thickness of 3 μm.

[0072]

Then, using a photomask 35 in which transmitting portions 17, light intercepting portions 18 and a semi-transmitting

portion 29 other than the portions 17 and 18 are mixed and the area of the transmitting portions 17 is in a range of from 20% to 40% as circular regions as shown in Fig. 7, exposure was uniformly performed at a high illuminance as shown in Fig. 6(b). It is preferable that the exposure amount at this time is in a range of from 160 mj to 500 mj. In this embodiment, exposure was performed with an exposure amount of 240 mj. At this time, the area of the circular or polygonal transmitting portions 17 of the photomask was 30%, the transmitting portions 17 were randomly disposed so that the center-to-center distances between adjoining transmitting portions 17 were in a range of from 5 μm to 50 μm, preferably, 10 μm to 20 μm, the light intercepting portions 18 were disposed in the regions corresponding to the contact holes 30, and the semi-transmitting portion 29 whose light transmittance was 17% of that of the transmitting portions was disposed in the region other than the portions 17 and 18. Although not shown, the region other than the display region is a light intercepting region.

[0073]

The succeeding process is similar to that of the above-described Embodiment 1. Development was performed as shown in Fig. 6(c), and a heat treatment was performed as shown in Fig. 6(d), so that smooth asperities were formed by the resin being deformed.

[0074]

Then, as shown in Fig. 6(e), an Al thin film was formed as the reflecting electrode 10 on the substrate 1, and as shown in Figs. 6(f) to (j), patterning was performed so that one reflecting electrode 10 corresponds to one transistor.

[0075]

By the above-described process, the reflecting electrode 10 having smooth and high-density asperities was formed. In such a reflecting substrate 23, the area of the flat part is reduced, so that ideal reflection characteristics with a small regular reflection component can be realized. Moreover, the number of photoprocesses of the photosensitive resin can be reduced, so that the cost necessary for the manufacture of the reflecting plate can be reduced.

[0076]

Lastly, the reflecting substrate 23 and a color filter substrate for supporting a transparent electrode are bonded together with a spacer therebetween in a manner similar to that of the prior art, liquid crystal is filled, and a retardation film and a polarizer are bonded to the color filter substrate to complete the reflective-type liquid crystal display apparatus according to this embodiment.

[0077]

In the reflective-type liquid crystal display apparatus according to this embodiment, while the reflecting electrode

having smooth and high-density reflecting asperities is formed like in the above-described Embodiment 1, the number of exposures can further be reduced by using the photomask having the semi-transmitting portion in the photoprocess of the photosensitive resin, so that the cost necessary for the manufacture of the reflecting substrate can be reduced.

[0078]

(Embodiment 3)

Hereinafter, a reflective-type liquid crystal display apparatus according to Embodiment 3 of the invention will be described with reference to the drawings. The reflecting substrate of the reflective-type liquid crystal display apparatus according to this embodiment is the same as the reflecting substrate shown in Fig. 1 but is formed by a different manufacturing method. The manufacturing method will be described with reference to the cross-sectional views shown in Fig. 8.

[0079]

Fig. 8 shows cross-sectional views showing a manufacturing process of the reflecting substrate used in the reflective-type liquid crystal display apparatus according to this embodiment. In these figures, the pixel region is shown on the left side, and the signal input terminal portion region is shown on the right side.

[0080]

First, as shown in Fig. 8(a), the negative photosensitive resin 9 (the name of the product: FE301N manufactured by Fuji Film Olin) is applied to the glass substrate 1 in a thickness of 1 to 5 μm. In this embodiment, the resin 9 was applied in a thickness of 3 μm.

[0081]

Then, by using the second photomask 20 in which the area of the transmitting portions 17 was in a range of from 20% to 40% as circular regions in the region other than the contact hole portions 30 as shown in Fig. 5, the region other than the contact hole portions 30 was uniformly exposed at a low illuminance as shown in Fig. 8(b). It is desirable that the exposure amount at this time is 20 mj to 100 mj. In this embodiment, exposure was performed with an exposure amount of 40 mj. At this time, the circular or polygonal transmitting portions 17 of the second photomask were randomly disposed so that the center-to-center distances between adjoining transmitting portions 17 were in a range of from 5 μm to 50 μm, preferably, 10 μm to 20 μm.

[0082]

Then, by using the first photomask 19 in which the light intercepting portions 18 corresponding to the contact hole portions 30 were disposed as shown in Fig. 4, the region other than the contact hole portions 30 was uniformly exposed with an exposure amount of 40 mj which was the same as that in the

above-described first exposure process as shown in Fig. 8(c). The first and the second photomasks were structured so as to intercept the signal input terminal portion 27 from light as well as the contact hole portions.

[0083]

Then, as shown in Fig. 8(d), by performing development with a developing solution TMAH (tetramethylammoniumhydrooxide) manufactured by Tokyo Ohka Kogyo Co., Ltd., the resin in the unexposed part (the contact hole portions and the signal input terminal portion) was completely removed, approximately 30%, with respect to the initial film thickness, of the resin in the part exposed once was left, and approximately 70%, with respect to the initial film thickness, of the resin in the part exposed twice was left.

[0084]

Then, as shown in Fig. 8(e), by performing a heat treatment at 200℃ for 60 minutes, the resin of the above-described condition was deformed into smooth asperities.

[0085]

The succeeding process is similar to that of the above-described Embodiments 1 and 2. As shown in Fig. 8(f), an Al thin film was formed as the reflecting electrode 10 on the substrate 1, and as shown in Figs. 8(j) to (k), patterning was performed so that one reflecting electrode 10 corresponds to one transistor.

[0086]

By the above-described process, the reflecting electrode 10 having smooth and high-density asperities was formed. In such a reflecting substrate 23, the area of the flat part is reduced, so that ideal reflection characteristics with a small regular reflection component can be realized. Moreover, the number of photoprocesses of the photosensitive resin can be reduced, so that the cost necessary for the manufacture of the reflecting plate can be reduced.

[0087]

Lastly, the reflecting substrate 23 and a color filter substrate for supporting a transparent electrode are bonded together with a spacer therebetween in a manner similar to that of the prior art, liquid crystal is filled, and a retardation film and a polarizer are bonded to the color filter substrate to complete the reflective-type liquid crystal display apparatus according to this embodiment.

[0088]

In the reflective-type liquid crystal display apparatus according to this embodiment, while the reflecting electrode having smooth and high-density reflecting asperities is formed like in the above-described Embodiment 1, the throughput of the apparatus improves by performing the first and the second exposures with the same exposure amount in the photoprocess of the photosensitive resin, and the cost necessary for the

manufacture of the reflecting substrate can be reduced.

[0089]

(Embodiment 4)

Hereinafter, a transmissive/reflective type liquid crystal display apparatus according to Embodiment 4 of the invention will be described with reference to the drawings. Fig. 9 is a plan view showing a substrate of the transmissive/reflective type liquid crystal display apparatus according to this embodiment. Fig. 10 is a cross-sectional view of the substrate shown in Fig. 9. Fig. 11 shows cross-sectional views showing the flow of the manufacturing process of the substrate.

[0090]

As shown in Figs. 9 and 10, in the substrate 23 used in the transmissive/reflective type liquid crystal display apparatus according to this embodiment, one pixel electrode formed on the substrate 23 is divided into a reflecting region in which the reflecting electrode 10 is formed and a transmitting region 31 in which a transparent electrode is formed. The reflecting electrode 10 has on the surface thereof smooth and high-density asperities comprising the circular concave or convex portions like in Embodiments 1 to 3.

[0091]

With this structure, the transmissive/reflective type liquid crystal display apparatus according to this embodiment

can be used as a reflective-type liquid crystal display apparatus when the ambient light is so strong that the display is dimmed in a transmissive liquid crystal display apparatus, and can be used as a transmissive liquid crystal display apparatus by turning on the backlight when the display cannot be clearly viewed in the reflective-type liquid crystal display apparatus because of a dim environment.

[0092]

In the transmissive/reflective type liquid crystal display apparatus according to this embodiment, as shown in Figs. 9 and 10, an amorphous silicon transistor is formed on the glass substrate 1 as the liquid crystal driving device 24. The liquid crystal driving device 24 comprises Ta as the gate electrode 2 on the glass substrate 1, SiNx as the gate insulating layer 3, a-Si as the semiconductor layer 4, n-type a-Si as the n-type semiconductor layer 5, the source electrode 7 and the drain electrode 8 made of ITO, and a Ta layer 32 formed on the electrodes 7 and 8. The ITO of the drain electrode 8 is extended to the pixel region to form the transparent electrode formed in the transmitting region.

[0093]

Although not shown in this embodiment, the signal input terminal portion 27 for inputting signals to the gate bus line and the source bus line is similar to those of the above-described Embodiments 1 to 3.

[0094]

A manufacturing process of the substrate 23 of the transmissive/reflective type liquid crystal display apparatus according to this embodiment will be described with reference to Fig. 11. In Fig. 11, the ITO being present in the transmitting region 31 is omitted.

[0095]

First, as shown in Fig. 11(a), the negative photosensitive resin 9 (the name of the product: OFPR-800 manufactured by Tokyo Ohka Kogyo Co., Ltd.) is applied to the glass substrate 1 in a thickness of 1 to 5 μm. In this embodiment, the resin 9 was applied in a thickness of 3 μm.

[0096]

Then, by using a first photomask 34 in which light intercepting portions 18 corresponding to the contact hole portions 30 and the transmitting region 31 were disposed as shown in Fig. 12, the contact hole portions 30 and the transmitting region 31 were uniformly exposed at a low illuminance as shown in Fig. 11(b). At this time, the first and the second photomasks were structured so as to intercept the signal input terminal portion 27 from light as well as the contact hole portions. It is desirable that the exposure amount at this time is 20 mj to 100 mj. In this embodiment, exposure was performed with an exposure amount of 40 mj.

[0097]

Then, by using a second photomask 36 in which transmitting portions 17 were disposed so as not to be present in the contact hole portions 30 and the transmitting region 31 as circular regions as shown in Fig. 13, exposure was uniformly performed at a high illuminance as shown in Fig. 11(c). It is desirable that the exposure amount at this time is 160 mj to 500 mj. In this embodiment, exposure was performed with an exposure amount of 240 mj using the second photomask 36 in which the area of the transmitting portions 17 was 30%. At this time, the area of the circular or polygonal transmitting portions 17 of the second photomask 36 was 30% of the area of the reflecting electrode and the transmitting portions 17 were randomly disposed so that the center-to-center distances between adjoining transmitting portions 17 were in a range of from 5 μm to 50 μm, preferably, 10 μm to 20 μm.

[0098]

Then, as shown in Fig. 11(d), by performing development with a developing solution TMAH (tetramethylammoniumhydrooxide) manufactured by Tokyo Ohka Kogyo Co., Ltd., the resin in the exposed part (the contact hole portions, the transmitting region and the signal input terminal portion) was completely removed, approximately 40%, with respect to the initial film thickness, of the resin in the part exposed at a low illuminance was left, and approximately 80%, with respect to the initial film thickness, of the resin in the

unexposed part was left.

[0099]

Then, as shown in Fig. 11(e), by performing a heat treatment at 200℃ for 60 minutes, the resin of the above-described condition was deformed into smooth asperities.

[0100]

The succeeding process is similar to that of the above-described Embodiments 1 to 3. As shown in Fig. 11(f), an Al thin film was formed as the reflecting electrode 10 on the substrate 1, and patterning was performed so that one reflecting electrode 10 corresponds to one transistor.

[0101]

By the above-described process, the substrate having the reflecting region comprising the reflecting electrode 10 having smooth and high-density asperities, and the transmitting region comprising the transparent electrode was formed. In the reflecting electrode on the substrate, the area of the flat part is reduced, so that ideal reflection characteristics with a small regular reflection component can be realized. Moreover, the number of photoprocesses of the photosensitive resin can be reduced, so that the cost necessary for the manufacture of the reflecting plate can be reduced.

[0102]

Lastly, the substrate 23 and a color filter substrate for supporting a transparent electrode are bonded together with

a spacer therebetween in a manner similar to that of the prior art, liquid crystal is filled, a retardation film and a polarizer are bonded to the color filter substrate and a backlight is set on the back surface of the substrate to complete the transmissive/reflective type liquid crystal display apparatus according to this embodiment.

[0103]

[Effect of the invention]

According to the invention, by exposing one layer of a photosensitive resin applied to the substrate with the different integrals of exposure amount on an area basis, smooth and high-density asperities can be formed, so that ideal reflecting means with a reduced flat area and a small regular reflection component can be formed. Consequently, the number of photoprocesses of the photosensitive resin can be reduced to thereby reduce the cost necessary for the manufacture.

[0104]

In the invention, since a negative photosensitive resin is used, the resin in a part that is not exposed because of the presence of dust or the like can be removed by development, so that electric continuity is ensured even when dust or the like adheres to the contact hole portions and the signal input terminal portion.

[BRIEF EXPLANATION OF THE DRAWINGS]

[Fig. 1]

Fig. 1 is a plan view of a reflecting substrate used in a reflective-type liquid crystal display apparatus according to an embodiment of the invention.

[Fig. 2]

Fig. 2 is a cross-sectional view of the reflecting substrate used in the reflective-type liquid crystal display apparatus according to an embodiment of the invention.

[Fig. 3]

Figs. 3(a) to (k) are cross-sectional views showing a manufacturing process of the reflecting substrate used in the reflective-type liquid crystal display apparatus according to an embodiment of the invention.

[Fig. 4]

Fig. 4 is a schematic plan view showing the patterns of a transmitting region and light intercepting region of a first photomask according to an embodiment of the invention.

[Fig. 5]

Fig. 5 is a schematic plan view showing the patterns of transmitting region and a light intercepting region of a second photomask according to an embodiment of the invention.

[Fig. 6]

Figs. 6(a) to (j) are cross-sectional views showing a manufacturing process of the reflecting substrate used in a reflective-type liquid crystal display apparatus according to an embodiment of the invention.

[Fig. 7]

Fig. 7 is a schematic plan view showing the pattern of a photomask according to an embodiment of the invention.

[Fig. 8]

Figs. 8(a) to (k) are cross-sectional views showing a manufacturing process of the reflecting substrate used in the reflective-type liquid crystal display apparatus according to an embodiment of the invention.

[Fig. 9]

Fig. 9 is a plan view of a reflecting substrate used in a transmissive/reflective type liquid crystal display apparatus according to an embodiment of the invention.

[Fig. 10]

Fig. 10 is a cross-sectional view of the reflecting substrate used in the transmissive/reflective type liquid crystal display apparatus according to an embodiment of the invention.

[Fig. 11]

Figs. 11(a) to (f) are cross-sectional views showing a manufacturing process of the reflecting substrate used in the transmissive/reflective type liquid crystal display apparatus according to an embodiment of the invention.

[Fig. 12]

Fig. 12 is a schematic plan view showing the patterns of a transmitting regions and light intercepting regions of a

first photomask according to an embodiment of the invention.

[Fig. 13]

Fig. 13 is a schematic plan view showing the patterns of transmitting regions and a light intercepting region of a second photomask according to an embodiment of the invention.

[Fig. 14]

Fig. 14 is a cross-sectional view showing the reflective-type liquid crystal display apparatus formed by the conventional manufacturing method.

[Fig. 15]

Figs. 15(a) to (e) are cross-sectional views showing the manufacturing process of the reflecting substrate in the conventional reflective-type liquid crystal display apparatus.

[Fig. 16]

Fig. 16 is a schematic plan view showing the patterns of the transmitting regions and the light intercepting region of the conventional photomask.

[Reference numerals]

1 glass substrate

2 gate line, gate electrode, terminal electrode made of the dame material as that of gate electrode

3 gate insulating layer

4 semiconductor layer

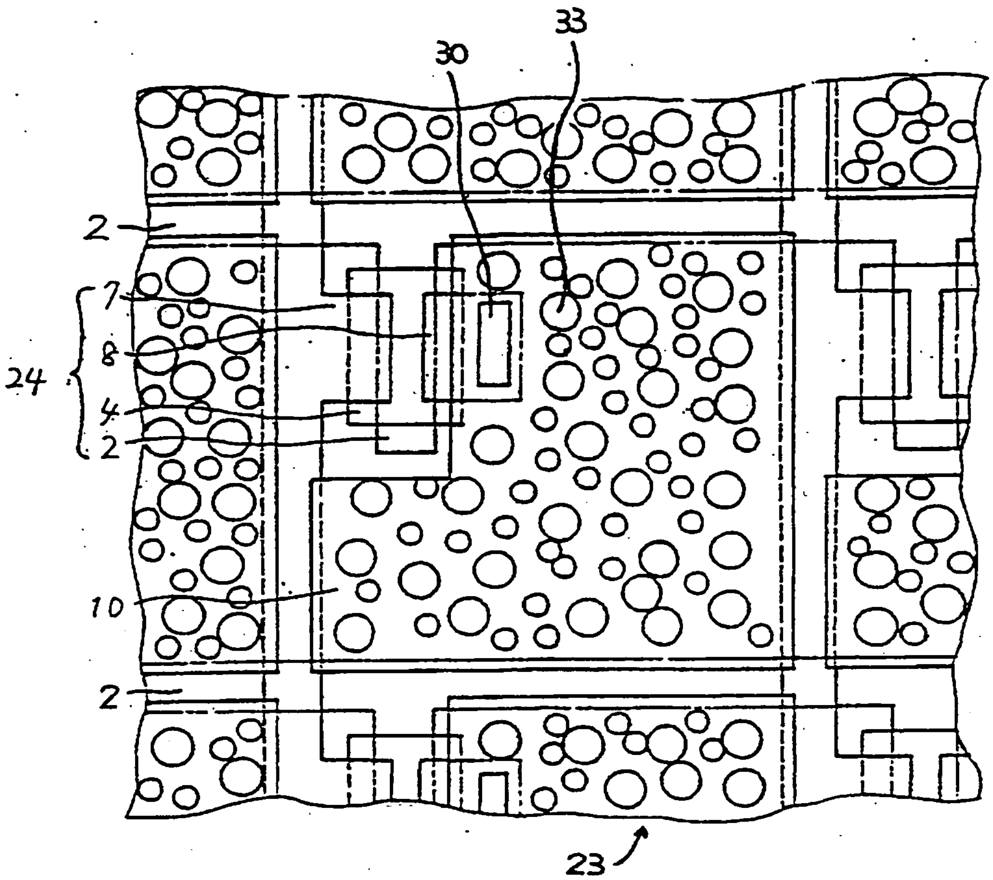
5 n-type semiconductor layer

6	etch stopper
7	source electrode
8	drain electrode
9	insulating layer between layers (positive photosensitive resin)
10	reflecting electrode
11	liquid crystal layer
12	ITO electrode
13	color filter
14	glass plate on the side of color filter
15	retardation film
16	polarizer
17	transmitting portion
18	light intercepting portion
19	first photomask
20	second photomask
21	photomask
22	UV light
23	reflecting substrate
24	liquid crystal driving device
25	color filter substrate
26	terminal connection electrode
27	signal input terminal portion
28	photoresist
29	semi-transmitting portion

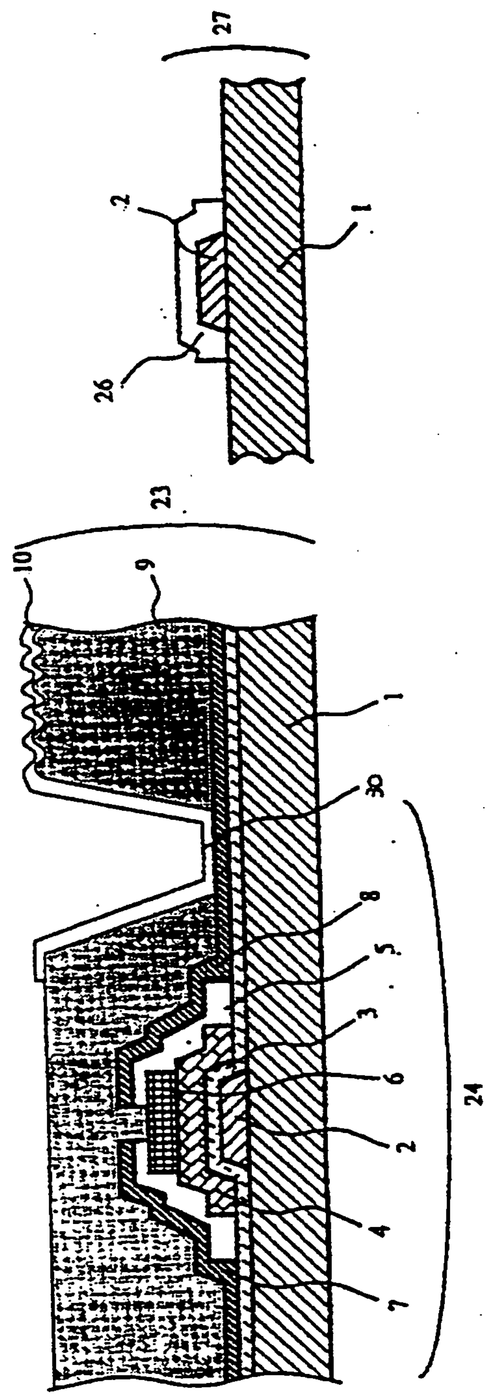
30	contact hole
31	transmitting region
32	metal layer
33	concave or convex portion
34	first photomask
35	photomask
36	second photomask

[DOCUMENT] DRAWINGS

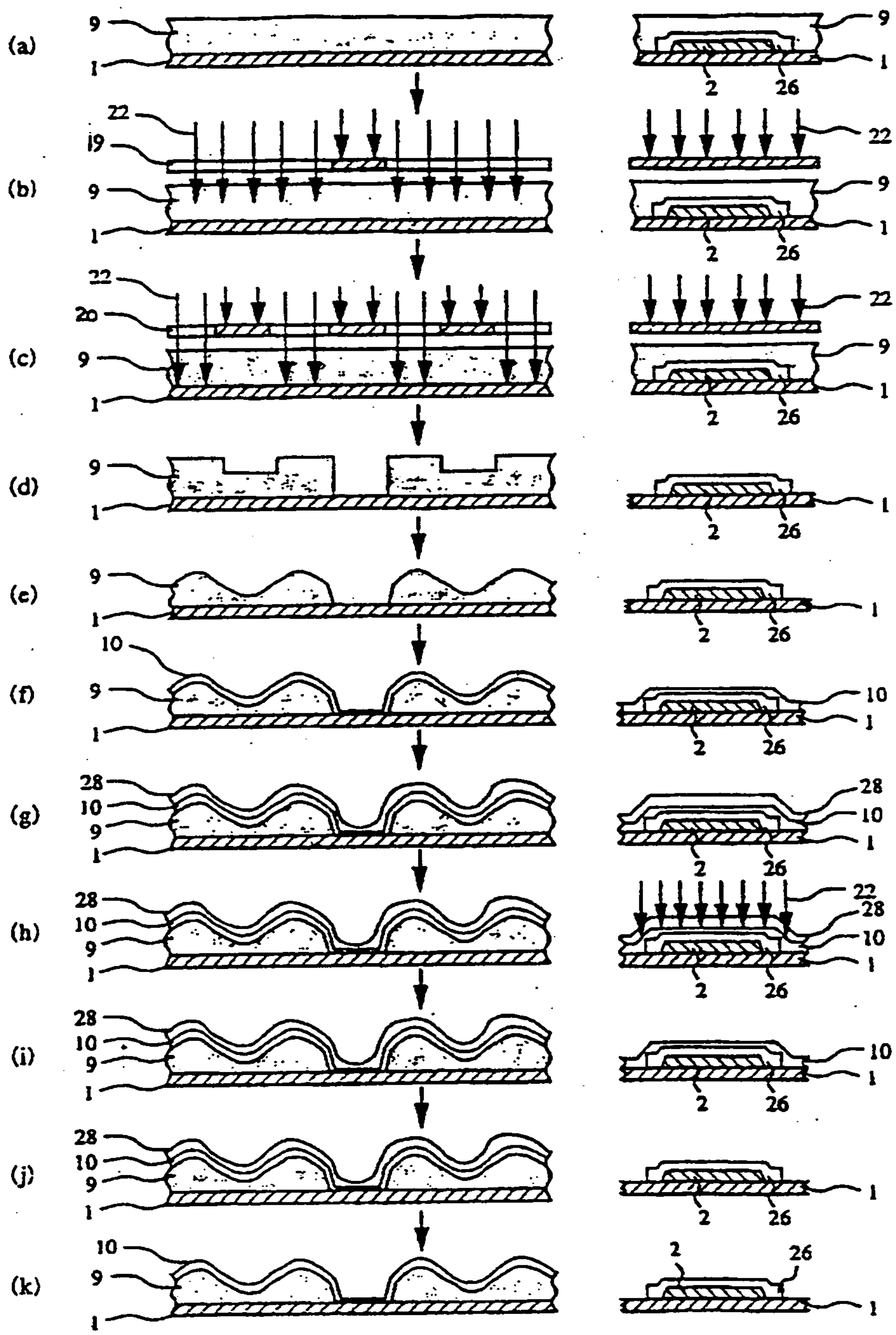
[Fig. 1]



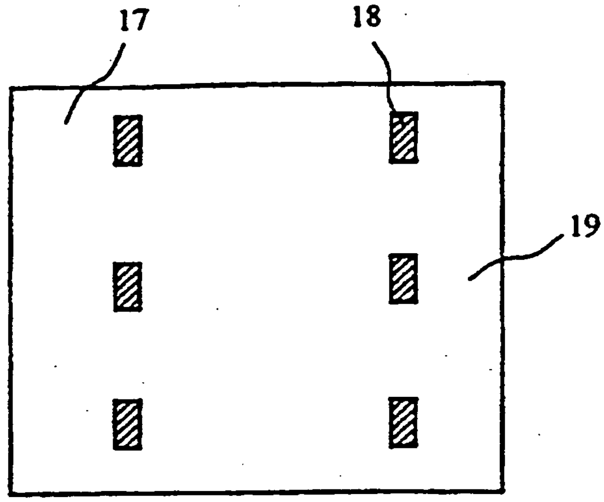
[Fig. 2]



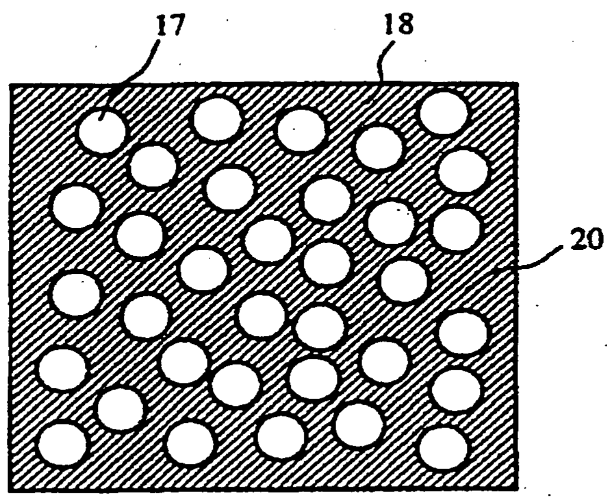
[Fig. 3]



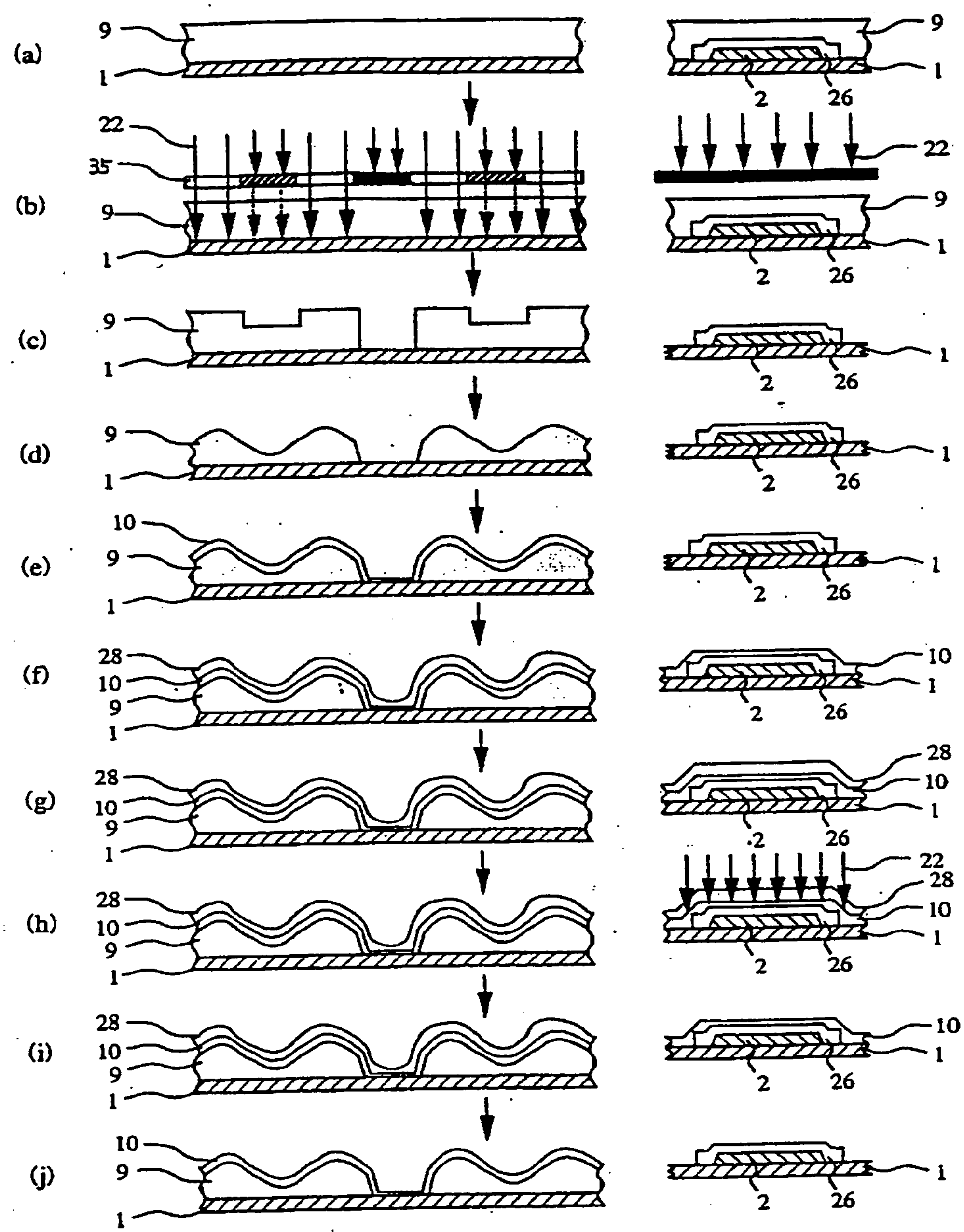
[Fig. 4]



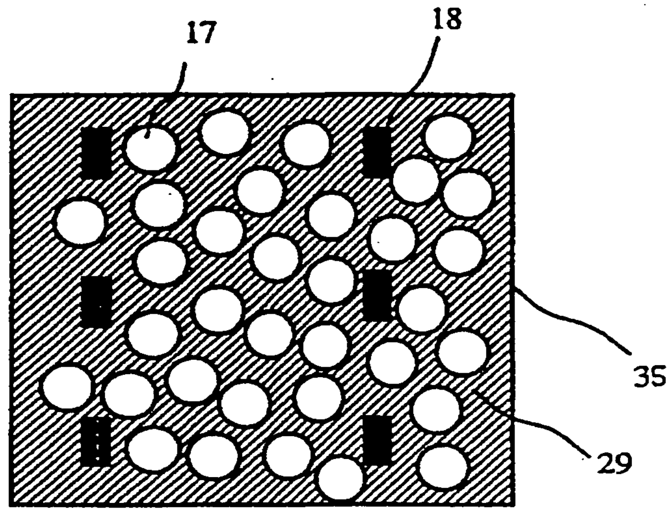
[Fig. 5]



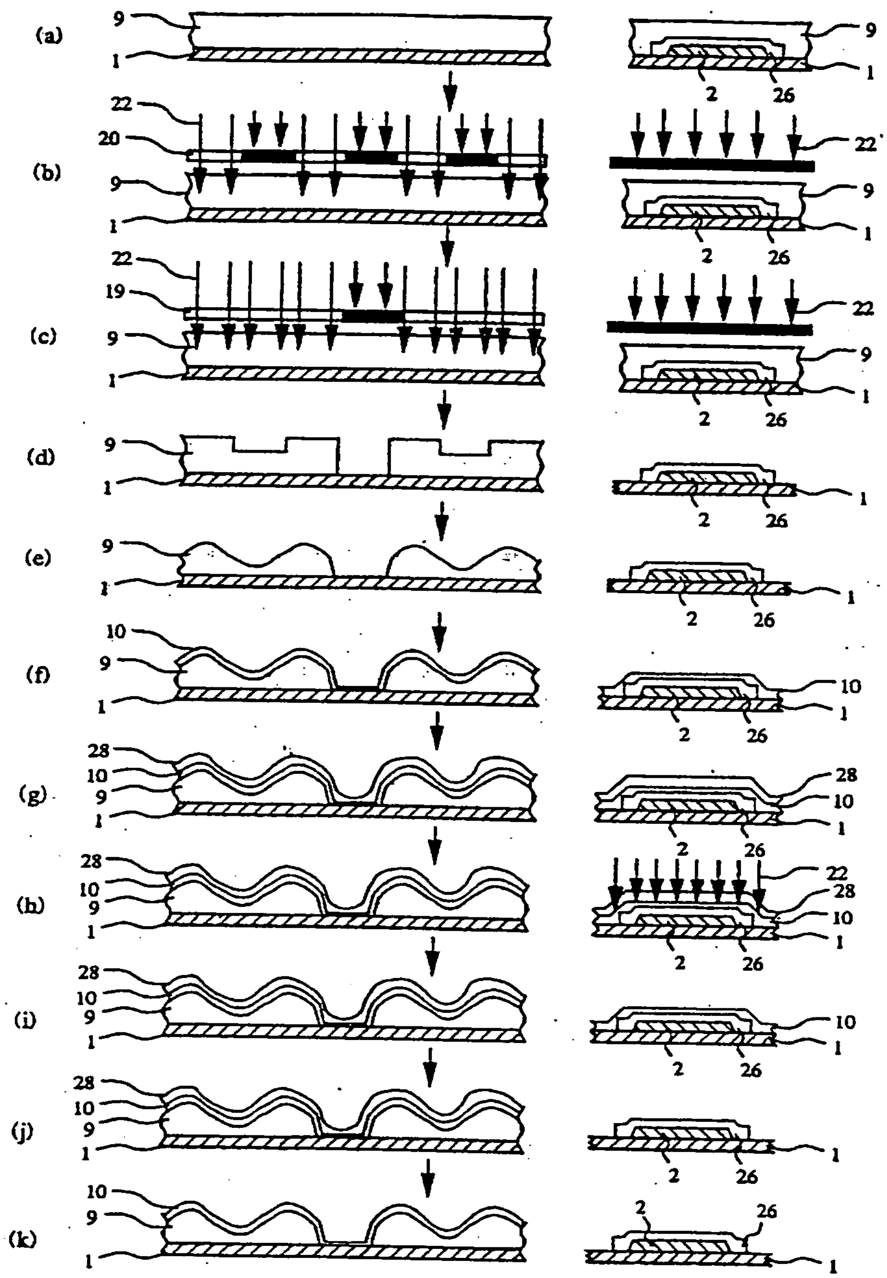
[Fig. 6]



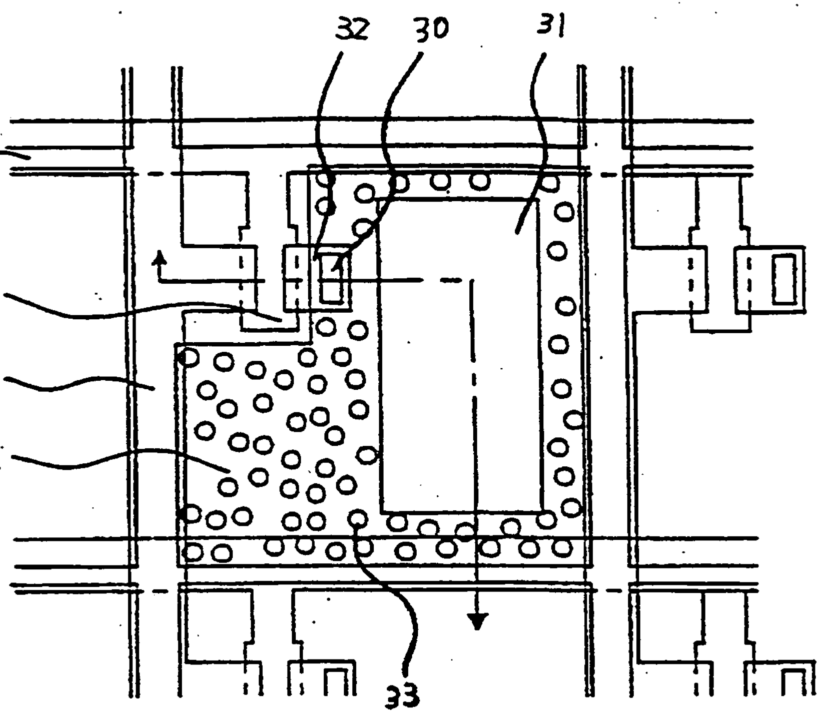
[Fig. 7]



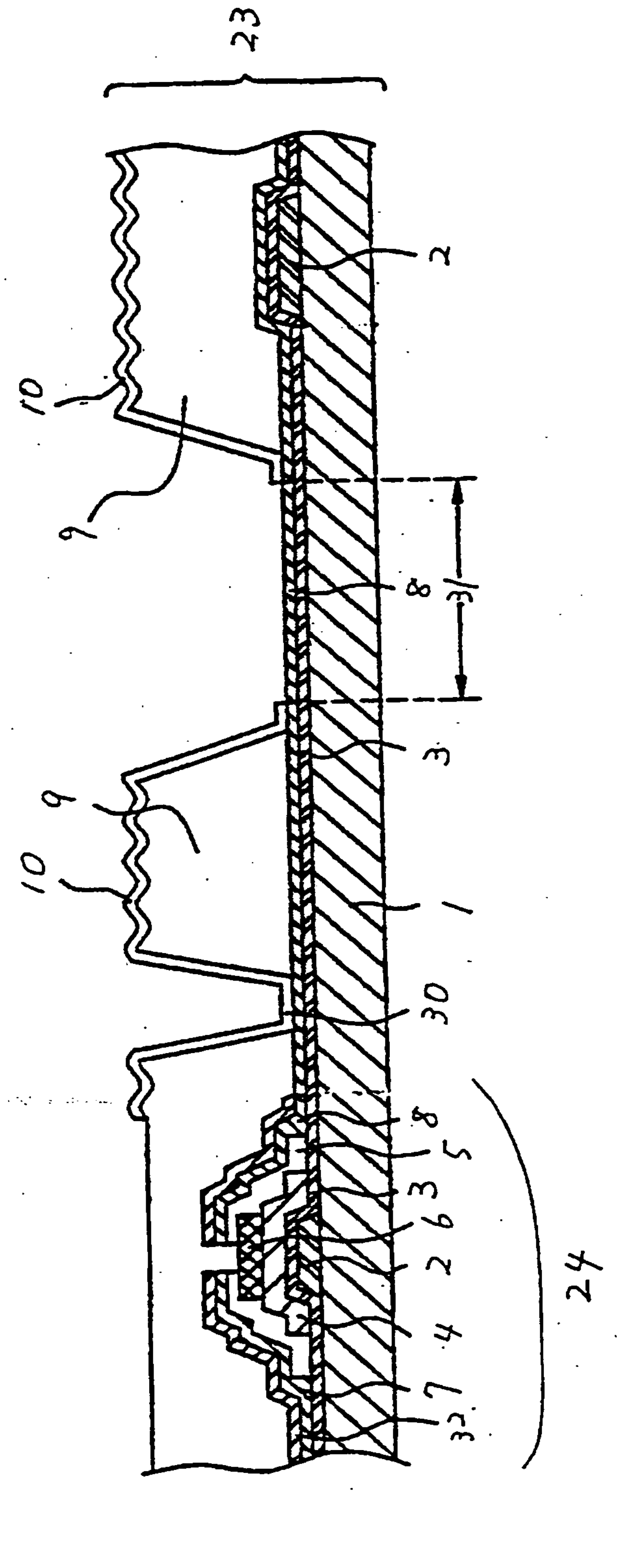
[Fig. 8]



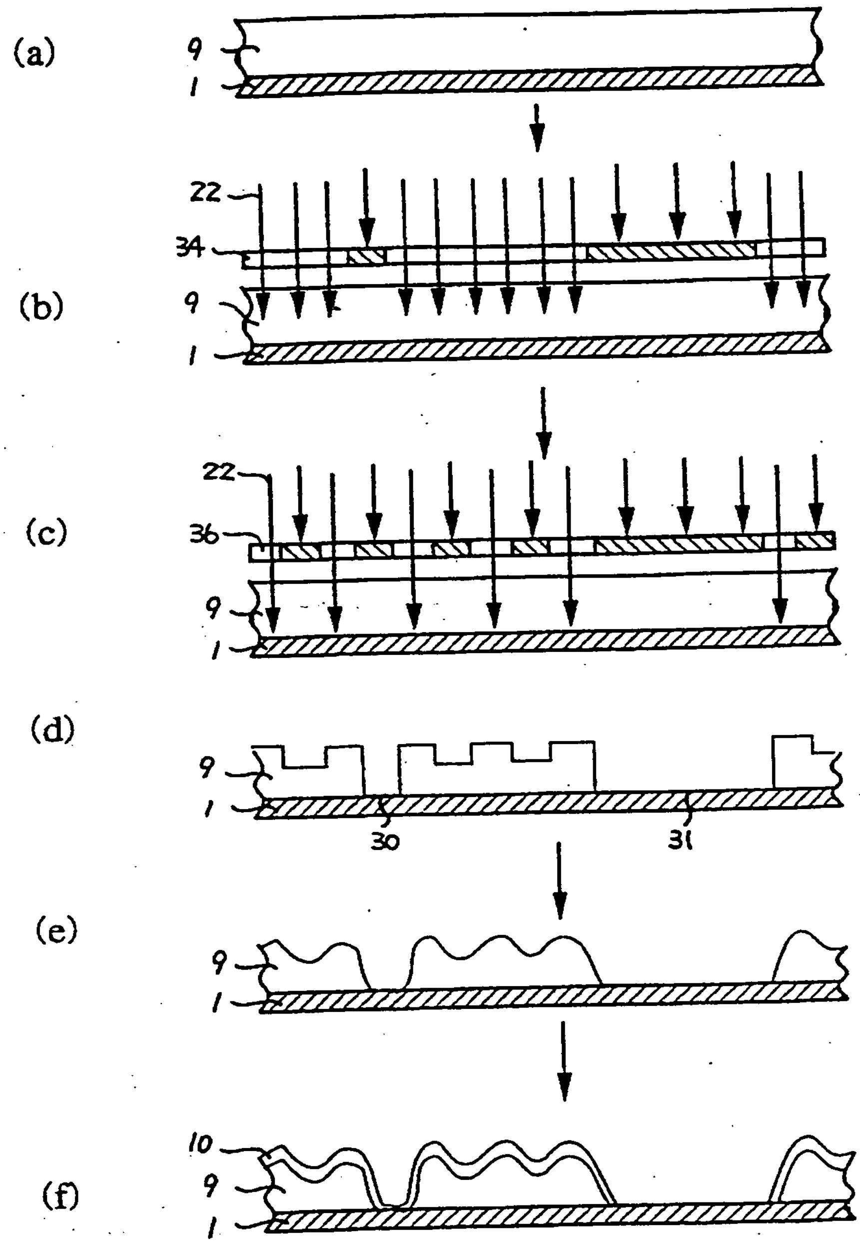
[Fig. 9]



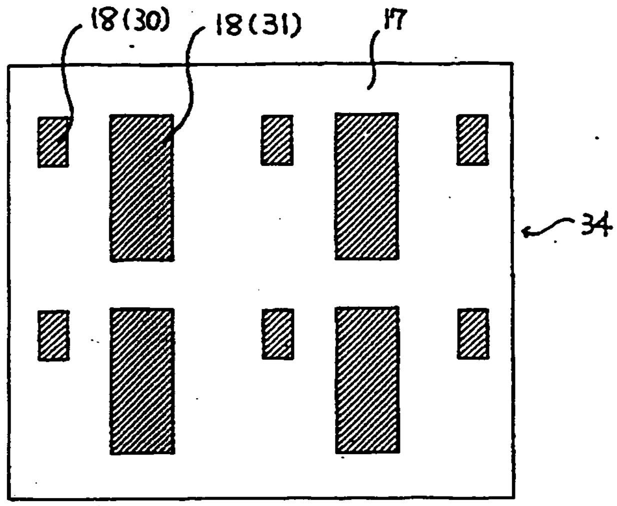
[Fig. 10]



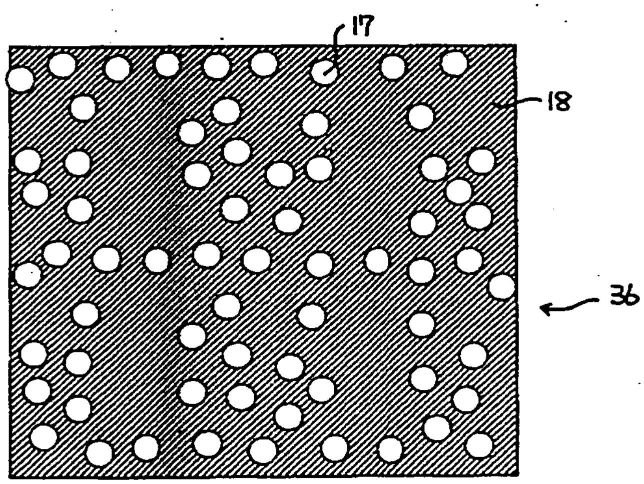
[Fig. 11]



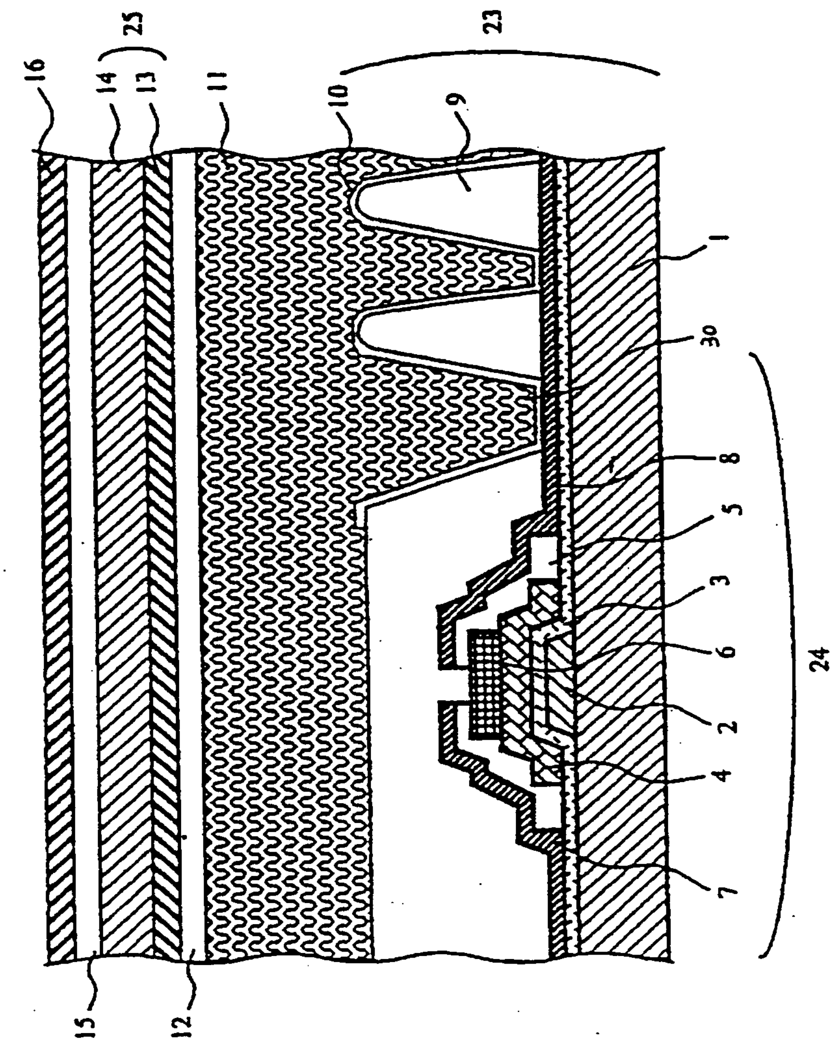
[Fig. 12]



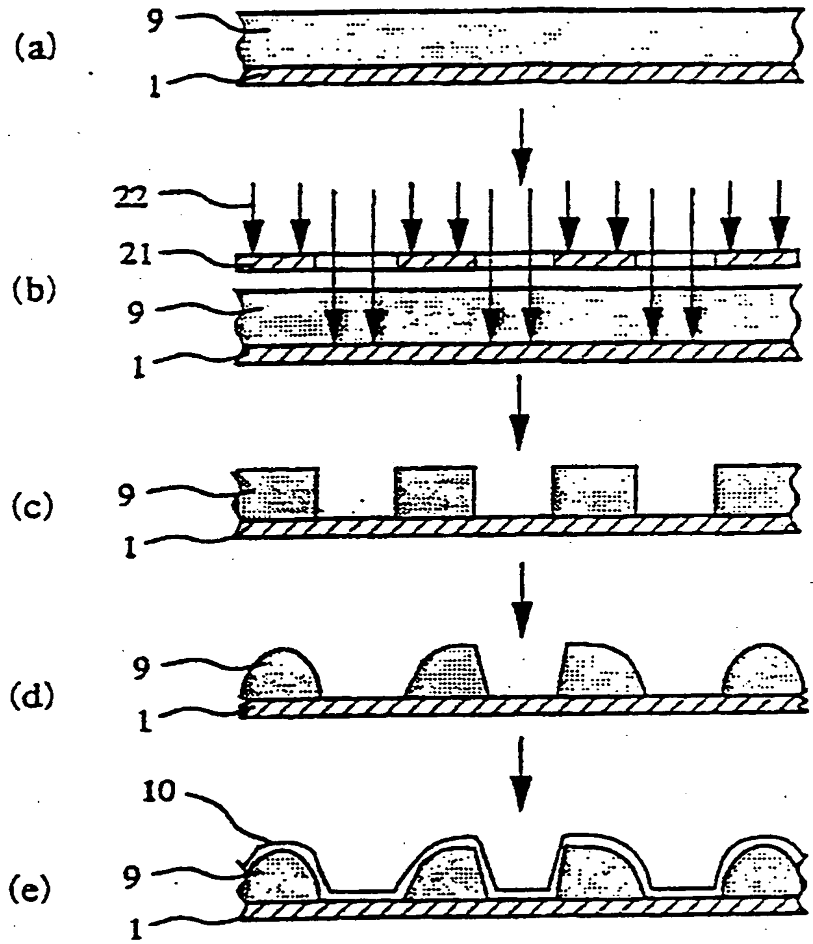
[Fig. 13]



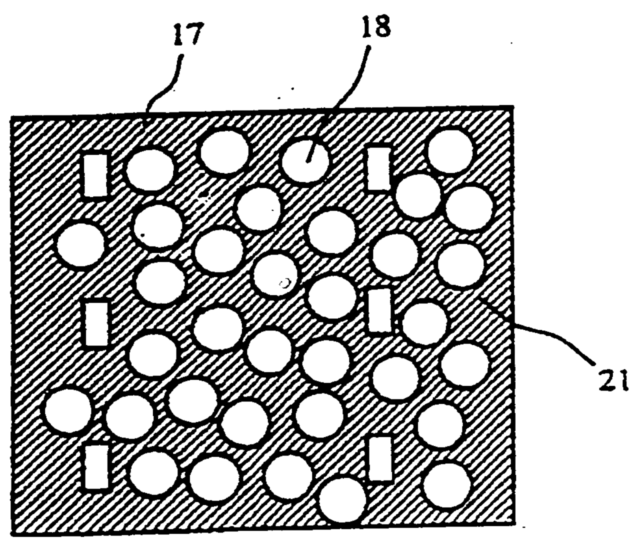
[Fig. 14]



[Fig. 15]



[Fig. 16]



[DOCUMENT] ABSTRACT

[ABSTRACT]

[OBJECT] An object of the invention is to provide a method of manufacturing a liquid crystal display apparatus of high display quality by which a reflecting plate having excellent reflection characteristics can easily be manufactured with excellent reproducibility.

[SOLUTION] A negative photosensitive resin is applied to a substrate, asperities are formed in a first region of the applied photosensitive resin film by exposing with various integrals of exposure amount so that the photosensitive resin in the first region is left in different film thicknesses and a concave is formed in a second region of the applied photosensitive resin film so that the photosensitive resin in the second region is left in a thickness smaller than those of the first region by exposing the second region with an integral of exposure amount different from those for the first region.

[FIGURE TO BE PUBLISHED] Fig. 2